Version 5 from Feb 9, 2015

ASTR 511: Galactic Astronomy

Željko Ivezić
University of Washington, Winter Quarter 2015

Location and Time: Tuesday 1:40-3:00, Thursday: 1:40-3:00 PAB B356

Office Hours: Any time when my office door is open;
Tue and Wed are the best, Mon and Thu are the worst.

Grading: closed-book final exam 20%, 3 homeworks 60%, term paper presentation 20%;
key: >90%=A, >80%=B, >70%=C, >50%=D.

Class web site: http://www.astro.washington.edu/users/ivezic/Astr511/

Required reading: Ivezić, Beers & Jurić 2012, ARA&A, 50, 251.

Reference Books: Binney & Merrifield: *Galactic Astronomy*
Reid & Hawley: *New Light on Dark Stars*
Binney & Tremaine: *Galactic Dynamics*
Sparke & Gallagher: *Galaxies in the Universe*

The main Goals for this Class are:

1. Familiarizing students with the motivation for studying galaxies in general, and the Milky Way in particular. Overview of the most relevant literature. Introduction to basic Galaxy components, galaxy formation theories, galaxy dynamics, and connection to dark matter.

2. Informing students about the current Galaxy research, including discussion of the expected observational and theoretical progress for the next decade.

3. Exposing students to practical problems through hands-on seminars, with emphasis on numerical methods and data mining, and using modern software engineering tools.

4. Training students to give professional talks.

Class Schedule (very tentative and subject to change)

1. **Tue: Jan 6 AAS meeting: NO CLASS**
2. **Thu: Jan 8 AAS meeting: NO CLASS**
3. **Tue: Jan 13** L1: Introduction to class, review of stellar astrophysics
4. **Thu: Jan 15** Software development tools: guest lecture by Mario Jurić
5. **Tue: Jan 20** L2: Open and globular clusters and simple stellar pops
6. **Thu: Jan 22** L3: Review of galaxy properties and galaxies in SDSS
7. **Tue: Jan 27** L4: Luminosity and mass functions
8. **Thu: Jan 29** L5: Basic properties of the Milky Way (MW) **HW 1 due**
9. **Tue: Feb 3** L6: Stellar count distribution in MW: part I
10. **Thu: Feb 5 NO CLASS**
11. **Tue: Feb 10** L6: Stellar count distribution in MW: part II
12. **Thu: Feb 12 NO CLASS**
13. **Tue: Feb 17** L7: Stellar metallicity distribution in MW **HW 2 due**
14. **Thu: Feb 19** L8: Stellar kinematics in MW: part I
15. **Tue: Feb 24** L8: Stellar kinematics in MW: part II
16. **Thu: Feb 26** L9: Evidence for dark matter in MW
17. **Tue: Mar 3** L10: The Road Ahead: Gaia and LSST
18. **Thu: Mar 5** Term paper presentations
19. **Tue: Mar 10** Term paper presentations
20. **Thu: Mar 12** Term paper presentations **HW 3 due**
21. **Tue: Mar 17** FINAL EXAM

Homework

There will be three homeworks, designed as term projects. All three will be similar from the technical point of view: they will involve reading a number of vectors with several million elements from provided files (using python and ipython notebooks), simple operations with these vectors such as binning and low-order statistics, and visualization of your results.

The problems and links to data files will be posted at the class website about two weeks before the homework is due. They will address these three general themes:

1. Stellar number density distribution in MW
2. Determination of luminosity function
3. Stellar metallicity distribution in MW

We will attempt to use modern software engineering tools, such as github for version control and ipython notebooks for HW submission.

Selected Papers for Presentation:

Pick one by Jan 22, and send me e-mail with your choice.

1. Bahcall, J.N. & Tremaine, S. 1981 (ApJ 244, 805) *Methods for determining the masses of spherical systems. I - Test particles around a point mass*
2. Dehnen, W. & Binney, J.J. 1998 (MNRAS 298, 387) *Local stellar kinematics from HIPPARCOS data*
3. Helmi, A. & White, S.D.M. 2001 (MNRAS 323, 529) *Simple dynamical models of the Sagittarius dwarf galaxy*
4. Ibata, R., et al. 2001 (ApJ 551, 294) *Great Circle Tidal Streams: Evidence for a Nearly Spherical Massive Dark Halo around the Milky Way*
5. Jaffe, W. 1983 (MNRAS 202, 995) *A simple model for the distribution of light in spherical galaxies*
6. Kuijken, K. & Gilmore, G. 1991 (ApJ 367, L9) *The galactic disk surface mass density and the Galactic force K(z) at Z = 1.1 kpc*

7. Kuijken, K. & Tremaine, S. 1994 (ApJ 421, 178) *On the ellipticity of the Galactic disk*
8. Navarro, J.F., Frenk, C.S. & White, S.D.M. 1996 (ApJ 462, 563) *The Structure of Cold Dark Matter Halos*
9. Spitzer, L. & Schwarzschild, M. 1953 (ApJ 118, 106) *The Possible Influence of Interstellar Clouds on Stellar Velocities. II*
10. van den Bosch, F.C. & Dalcanton, J.J. 2000 (ApJ 534, 146) *Semianalytical Models for the Formation of Disk Galaxies. II. Dark Matter versus Modified Newtonian Dynamics*
11. Walsh, Willman & Jerjen 2009 (AJ, 137, 450) *The Invisibles: A Detection Algorithm to Trace the Faintest Milky Way Satellites*
12. Johnston et al. 2008 (ApJ, 689, 936) *Tracing Galaxy Formation with Stellar Halos*
13. Kauffmann et al. 2003 (MNRAS, 341, 33) *Stellar Masses and Star Formation Histories for 80,000 Galaxies from the Sloan Digital Sky Survey*
14. McGurk et al. 2010 (AJ, 139, 1261) *Principal Component Analysis of SDSS Stellar Spectra*
15. Sesar et al. 2010 (ApJ, 708, 717) *Light Curve Templates and Galactic Distribution of RR Lyrae Stars from Sloan Digital Sky Survey Stripe 82*
16. Schlaufman et al. 2009 (ApJ, 703, 2177) *Insight into the Formation of the Milky Way Through Cold Halo Substructure. I. The ECHOS of Milky Way Formation*
17. Law and Majewski 2010 (ApJ, 714, 229) *The Sagittarius Dwarf Galaxy: A Model for Evolution in a Triaxial Milky Way Halo*
18. Beers et al. 2012 (ApJ, 746, 34) *The Case for the Dual Halo of the Milky Way*
19. Berry et al. 2012 (ApJ, 757, 166) *The Milky Way Tomography with SDSS. IV. Dissecting Dust*
20. Evans & Williams 2014 (MNRAS, 443, 791) *A very simple cusped halo model*

These papers are very relevant for our class and cover subjects that are not going to be discussed in detail. Choose a paper and prepare a 10 min long Powerpoint (or equivalent) presentation (presumably including the most important figures from the paper). Pretend you did the work yourself and are giving an invited talk at a meeting. There will be a 5 min long question and answer session after the talk. The purpose of this exercise is to 1) learn some science, 2) practice extracting relevant information from papers 3) practice giving talks.

Do not forget the following good practices: 1) empty your pockets (no loose change, keys, phone, and such), 2) talk slowly and sufficently loud, 3) don't look at the floor, control your audience with direct eye contact, don't turn your back to the audience, don't be agressive with the pointer, etc. 4) don't rush (don't overload your 10 min long presentation), concentrate on the most important points, 5) emphasize what are truly new, and, possibly, unexpected results. 6) comment on the limitations and pitfalls of the presented analysis; how do we know it's right, could it be wrong?